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**STANDARD**

The present invention relates to a database management technique, and in particular, to a technique to manage a database resource when a program is activated according to a processing request to execute database processing.

A database language "structured query language (SQL)" has a function to call, as a routine, functions and procedures defined by a user. The functions and the procedures are analyzed when the routine is defined, and are registered to a database management system (DBMS) as an execution module related to a routine name. An execution module is produced as follows. A sequence of database processing procedures are analyzed to be converted into a format executable in the database management system. An execution module is also called "execution plan". When a routine call is issued and a routine name specified as information of the routine call, database processing is executed according to an execution module registered in association with the routine name.

On the other hand, an article "SOLJ-Part 1:

SQL Routines using the Java Programming Language,  
SIGMOD Record, Vol. 28, No. 4, December 1999" describes  
a function to execute, as a routine, a program written  
in the Java programming language. Java is a trademark  
5 or a registered trademark of Sun Microsystems, Inc. of  
the United States.

In this function, when a routine is defined,  
a program is registered in association with a routine  
name. In a routine call, a database management system  
10 executes a program in a program execution environment.  
When an SQL statement is issued, the program execution  
environment calls the database management system, and  
hence an execution module is generated and database  
processing is executed.

15 SUMMARY OF THE INVENTION

In an environment in which an SQL statement  
to be issued is determined when a program is executed  
in response to a routine call, an execution module is  
generated when the execution module is executed and a  
20 database resource to execute the SQL statement is also  
determined when the SQL statement is executed. The  
database resource includes, for example, a memory area  
necessary to execute the SQL statement and a cursor and  
a lock reserved to execute the SQL statement. Some  
25 items of the database resource must be kept reserved  
for the pertinent program until a transaction is  
completed. In the transaction completion, there is

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produced a sequence of SQL operations guaranteed as a minimum unit to recover a database. For a commit or rollback request, a transaction completion is carried out such that results of the database update by SQL statements occurring in the transaction are guaranteed or canceled.

In the above environment, the database resource necessary to execute SQL statements issued during the program execution is not under the control of the execution module to call a routine.

All items of the database resource are kept reserved until the transaction completion on the routine call side. When the transaction is completed, the items of the database resource are released at a time. As above, resources which to be used by other transactions are kept reserved for an unnecessarily long period of time, and hence the resource utilization efficiency is deteriorated in the overall system. To solve this problem, it is necessary to consider how to release the database resource related to an SQL statement issued during execution of a program.

United States Patent 6,006,235 issued to Macdonald et al on December 21, 1999 describes an approach and a method to execute, as a routine, a program described in an interpreter language such as the Java programming language. However, this patent does not mention the transaction completion during an execution of a program.

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It is therefore an object of the present invention, which has been devised to solve the above problem, to provide a database management method and a database management system to appropriately release a database resource which can be used by another program.

To solve the problem, a database management method according to one aspect of the present invention comprises a process for use in structured query language (SQL) query, of addressing to a commit request or a rollback request in a stored program written in a different-type of language or an interpreted language, the process comprising the steps of: reserving a resource at execution of a query from a stored program in the interpreted language and keeping relational information between the reserved resource and resources already reserved in the query processing in execution having invoke the program; and releasing, at release of a transaction from the stored program, associated ones of resources according to the relational information kept in said reserving step.

According to another aspect of the present invention, there is provided a database management method in a relational database system for addressing to a commit request or a rollback request in a stored program written in a different-type of language or an interpreted language (JAVA), said method comprising the steps of: reserving a resource at execution of a query from a stored program of an interpreted language and

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keeping relational information between the reserved resource and resources already reserved in the query processing in execution having invoked the program; and releasing, at release of a transaction from the stored  
5 program, associated ones of resources according to the relational information kept in said reserving step. As a result, a database resource which can be used by another program can be appropriately released.

Other objects, features and advantages of the  
10 present invention will become apparent from the description of the following embodiments of the invention taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

15 Fig. 1 is a block diagram showing a concept of the present invention,

Fig. 2 is a schematic diagram showing functional blocks and a hardware configuration of a database management system in an embodiment according  
20 to the present invention,

Fig. 3 is a flowchart showing a process of an SQL query processing section in an embodiment of the present invention to execute programs in an external program execution environment, and

25 Fig. 4 is a flowchart showing in detail step 330 of Fig. 3, namely, in which the external program execution environment of the embodiment executes

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## DESCRIPTION OF THE EMBODIMENTS

First, a concept of the present invention will be briefly described by referring to Fig. 1.

10 In the database management system of the embodiment, a routine is executed by an SQL query processing section 100, an external program execution environment 101, a resource reserving section 102, and a resource releasing section 103 as shown in Fig. 1.

15 The SQL query processing section 100 has a function to activate or to initiate an external program. In response to a routine call request from a user, the SQL query processing section 100 generates and executes an execution module 130. The section 100 accesses a

20 dictionary in a dictionary information storage area 110 and refer to relational information associated with routines and programs to determine a program to be activated. The SQL query processing section 100 issues a reservation request to the resource reserving section

25 102, specifically, issues a reservation request including a resource type 150 as a parameter to reserve a resource 140 in association with a routine call. The

resource reserving section 102 reserves the resource 140 and registers the resource type 150 to a release resource managing table 121 in a release resource management table storage area 111 and a resource managing table 122 in a resource managing table storage area 112. As a result of the above processing, the resource type 150 is registered as a currently reserved resource which cannot be released until the routine call is completely finished.

10           The SQL query processing section 100  
activates, according to the relational information  
obtained from the dictionary 120, an external program  
133 which is an entity of the routine. When the  
program 133 issues a select statement 134, the external  
15 program execution environment 101 issues an execution  
request to the SQL query processing section 100 to  
execute the select statement 134. According to the  
execution request, the SQL query processing section 100  
generates and executes an execution module 131. In  
20 this operation, the section 100 issues a reservation  
request including a resource type 151 as a parameter to  
the resource reserving section 102 to reserve a  
resource 141 associated with execution of the select  
statement. The resource reserving section 102 reserves  
25 the resource 141 and registers a resource type 151 to  
the resource managing table 122 in the resource manag-  
ing table storage area 112. As a result of the above  
processing, the resource type 151 is registered as a

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currently reserved resource.

When the program 133 issues a commit statement 135, the external program execution environment 101 issues a commit request to the SQL query processing section 100. The SQL query processing section 100 issues a resource release request to the resource release section 103. The section 103 refers to the release resource managing table 121 in the release resource management table storage area 111 and the resource managing table 122 in the resource managing table storage area 112 to determine a resource type 152 which can be released. The resource release section 103 deletes the resource type 152 from the resource managing table 122 in the resource managing table storage area 112. As a result of the above processing, the resource type 152 is released.

Next, Fig. 2 shows functional blocks and a hardware configuration of a database management system in an embodiment.

In the configuration of Fig. 2, a computer system 200 includes a central processing unit (CPU) 210, a main storage 211, external storages 202 such as magnetic disk devices, and a large number of terminals 201. In the main storage 211, the database management system 220 and the external program execution environment 101 are disposed. The external storages 202 store a database 251 and a dictionary 252 managed by the database management system 220. Additionally, a



processing program 250 to implement the database management system 220 and the external program execution environment 101 is stored also in the external storages 202.

5           The database management system 220 includes a system control section 230, an SQL query processing section 100, a database accessing section 231, and a dictionary accessing section 232. The system control section 230 includes a resource reserving section 102 and a resource releasing section 103. The resource reserving section 102 and the resource releasing section 103 operates the release resource managing table 121 and resource managing table 122. The SQL query processing section 100 has a function to activate an external program 104.

An SQL execution request issued by a user from the terminal 201 is executed as execution modules 240 and 241 in the SQL query processing section 100. When the requested SQL statement is a routine call, the section 100 issues a relational information acquisition request to the dictionary accessing section 232 to acquire information of a routine and the related program to be executed. The section 232 refers to relational information stored in the dictionary 252 and acquires pertinent relational information, and returns the acquired information to the SQL query processing section 100. The section 100 activates a program 242 according to the relational information. The program

The resource reserving section 102 in the system control section 230 reserves a resource necessary at SQL execution in the SQL query processing section 100 and registers a resource type to the release resource managing table 121 and the resource managing table 122. When a resource release request is received from the SQL query processing section 100, the resource releasing section 103 in the system control section 230 releases the resource, refers to the release resource managing table 121 and the resource managing table 122 to determine a resource to be released, and deletes the determined resource type from the resource managing table 122.

First, in step 301, the SQL query processing section 100 refers to the dictionary 120 to acquire

relational information of routines and programs. Next,  
in step 302, the section 100 passes as a parameter a  
resource type 150 for a routine call to the resource  
reserving section 102 to thereby issues a resource  
5 reservation request. In response thereto, the section  
102 registers the acquired resource type 150 to the  
release resource managing table 121 and the resource  
managing table 122 in step 310. Resultantly, in each  
of the release resource managing table 121 and the  
10 resource managing table 122, "definition R1" and  
"program P1" are kept stored in association with the  
resource type 150 as indicated by reference numeral 340  
in Fig. 3.

In step 303, the SQL query processing section  
15 100 activates an external program according to the  
relational information acquired in step 301. The  
external program execution environment 101 executes the  
specified program. The program processing executed in  
step 330 will be described in detail by referring to  
20 Fig. 4.

After the program execution processing is  
finished, the SQL query processing section 100 passes  
as a parameter the resource type 150 for the routine  
call to the resource releasing section 103 to thereby  
25 issues a resource release request in step 304. In  
response thereto, the section 103 deletes the resource  
type 150 received as a parameter from the release  
resource managing table 121 and the resource managing

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table 122 in step 320. Resultantly, in the release resource managing table 121 and the resource managing table 122, the items of the resource type 150 are not stored as indicated by a reference numeral 341. In the  
5 above procedure, the program call processing is executed in the SQL query processing section 100.

Fig. 4 shows details of step 330 of Fig. 3 in a flowchart. Specifically, the external program execution environment 101 in the embodiment of Fig. 1  
10 executes processing of a program 133, issues a select statement 134 and a commit statement, and calls the SQL query processing section 100. Steps 410 to 413 and steps 430 to 432 are executed by the SQL query processing section 100, step 420 is executed by the resource  
15 reserving section 102, step 440 is executed by the resource releasing section 103, and steps 400 to 403 are executed by the external program execution environment 101.

First, in step 401, the external program  
20 execution environment 101 determines whether or not a SQL statement has been issued from a program. If this is the case, control goes to step 410 to start SQL execution processing. In step 411, the SQL query processing section 100 analyzes an issued SQL state-  
25 ment. As a result of the analysis, the section 100 determines a resource type 151 of a resource necessary to execute the SQL statement. In step 412, the SQL query processing section 100 passes as a parameter the

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resource type 151 to the resource reserving section 102 to thereby issue a resource reservation request. In response thereto, the section 102 registers the resource type received as a parameter to the resource managing table 122. As a result, in the resource managing table 122, "table T1" and "index I1" are added as items of the resource type 151 to the state 340 of Fig. 3. That is, four items "definition R1", "program P1", "table T1", and "index I1" are kept as items of the resource type 151 as indicated by a reference numeral 450 in Fig. 4. After the execution of steps 411 and 412, the SQL query processing section 100 terminates the SQL statement execution processing, and then control returns to the external program execution environment 101.

In step 401, if the SQL statement has not been issued, control goes to step 402. In step 402, the external program execution environment 101 determines whether or not a commit statement has been issued from a program 133. If the commit statement has been issued, control goes to step 430 to start processing of the commit statement. In step 431, the SQL query processing section 100 issues a resource release request to the resource releasing section 103. In response thereto, the section 103 refers to the release resource managing table 121 and the resource managing table 122 to determine a resource type 152 to be released. In this situation, resources "table T1" and

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"index I1" which are kept in the resource managing table 122 and which are not kept in the release resource managing table 121 in the state indicated by a reference numeral 450 are determined to be deleted, and  
5 hence, a resource type 152 is determined to be released. The resource releasing section 103 then deletes the items of the resource type 152 from the resource managing table 122. As a result, "table T1" and "index I1" as the resource type 152 are deleted  
10 from the resource managing table 122 as indicated by a reference numeral 451 in Fig. 4. That is, only "definition R1" and "program P1" are kept remained therein. After the execution of step 431, the SQL query processing section 100 terminates the commit  
15 statement processing and then control returns to step 401 of the external program execution environment 101.

In step 402, if the commit statement has not been issued, the program execution processing is terminated. Through the above procedure, the program  
20 execution processing is conducted in the external program execution environment 101.

The processing of the flowcharts shown above is executed as programs in the computer system 200 shown in Fig. 2. However, it is not restricted that  
25 the programs are stored in an external storage physically externally connected to the computer system 200 as shown in Fig. 2. The programs may be stored on computer-readable storage media such as a hard disk

and/or a floppy disk for which the computer system 200  
can conduct read and write operations. Moreover, the  
programs may be stored via a network in an external  
storage of another computer system different from the  
5 computer system 2 of Fig. 2.

In the above embodiments, non-releasable  
database resources are kept in the release resource  
managing table 121. However, the release resource  
managing table 121 may be omitted. By adding informa-  
10 tion indicating a non-releasable state to the resource  
managing table 122, information of non-releasable  
database resources can be obtained from the table 122.

In the description of the present invention,  
although the commit statement is used as an example, a  
15 rollback statement may also be used in a similar  
fashion.

According to the present invention, the  
transaction completion can be conducted during the  
program execution. Therefore, for a user who conducts  
20 database processing can use, directly as a routine call  
program, a program including transactions. This  
increases portability and hence enhances the advantage  
of the stored program function.

According to the present invention, database  
25 resources which can be used by another program can be  
appropriately released.

While the present invention has been  
described with reference to the particular illustrative

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embodiments, it is not to be restricted by those  
embodiments but only by the appended claims. It is to  
be appreciated that those skilled in the art can change  
or modify the embodiments without departing from the  
5 scope and spirit of the present invention.

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